TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 185

THE INFLUENCE OF INLET AIR TEMPERATURE AND JACKET WATER TEMPERATURE ON INITIATING COMBUSTION IN A HIGH SPEED COMPRESSION IGNITION ENGINE.

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This paper deals with some tests to determine the influence on initiating combustion in a one-cylinder compression ignition engine of (1) inlet air temperature, and (2) jacket water temperature.

The engine used was a single cylinder Liberty, 5" bore × 7" stroke, fitted with a special piston of a magnesium alloy which gave a volumetric compression ratio about 11.4. This ratio gave compression ignition of gas oil (Diesel engine oil, sp. gr. 0.86 at 60° F.) in a warm engine. The head of the piston projected into the combustion chamber about one inch farther than the standard piston which gives 5.4 compression ratio. Fig. 1 shows the increased area of exposed piston as compared with the normal piston. Fig. 1 shows also the unfavorable form of combustion chamber, composed of an annular space of wedge section around the piston head and a shallow space over the piston. This combustion chamber form provided no core of hot air into which the fuel could be injected.

The injection system included a spring-actuated plunger pump supplied with fuel by a gear primary pump, and an automatic injection valve. The automatic injection valve, using impact of the jet against a lip integral with nozzle tip for atomizing, gave a fan-shaped spray directed across the combustion chamber. A characteristic of the spring-actuated fuel pump is, that the interval of injection, in seconds, is practically constant for a given pump stroke at all R.P.M.; the interval in terms of degrees of crank travel is, therefore, not constant. This means that as the R.P.M. is increased, assuming the same advance of the pump cam, less fuel is available for early vaporization before the piston reaches top dead center.

The influence of inlet air temperature and jacket water temperature on initiating combustion was measured in terms of the final compression pressure at which compression ignition occurred. Changes in final compression pressure were obtained by increasing the pressure at the beginning of the compression stroke (or the initial compression pressure), which pressure changes were effected by utilizing the inertia of the incoming air in a long intake pipe. Hence changes in final compression pressure were obtained in these tests, with no change in the volumetric compression ratio that would have given a corresponding temperature increase. The relation between final compression pressure and R.P.M. for the 62" and 70" lengths of inlet pipe was determined previous to these tests and is shown on Fig. 2..* The final compression pressure was chosen as a measure of the influence

* For more complete data see N.A.C.A. Technical Note No. 180.

of inlet air temperature and jacket water temperature because of its relationship to the initial compression pressure and because of the facility with which it could be determined.

During the tests to determine the influence of jacket water temperature, the operations were as follows. First, the jacket water in the supply tank was heated to the desired temperature. The engine was then motored over at 800 R.P.M. for two minutes, for all runs, in order to stabilize the temperature conditions in the cylinder walls and piston; meanwhile the length of the telescopic intake pipe was adjusted to 70 inches. The engine was then quickly speeded up, with the fuel pump set at the same length of stroke for all runs, until compression ignition was initiated, at which instant the R.P.M. and the jacket water temperature at the outlet from the cylinder were noted. The fuel was shut off immediately the engine had started firing, and the piston allowed to cool. Following this, a check run was made with a 62" length of intake pipe. The compression pressure for the R.P.M. at the instant of firing and the length of intake pipe was obtained from the curves shown in Fig. 2.

In the tests to determine the influence of inlet air temperature, a thermometer was inserted in the intake pipe close to the inlet valve, and the telescopic intake pipe adjusted to 62". The engine was motored over at 600 R.P.M. while the inlet air temperature was being regulated. Then the engine was speeded up and the R.P.M. and the inlet air thermometer reading at the instant of firing were taken. In order to average the lag of the thermometer, runs were made with increasing and decreasing air temperatures. During these runs the jacket water temperature at the outlet ranged between 55° and 60°F. The curves on Fig. 2 were again used for expressing R.P.M. in terms of final compression pressure.

Figs. 3, 4, 5 and 6 give the curves showing the effect of jacket water temperature on the compression pressure necessary for starting with two sizes of nozzle orifice, 0.014" and 0.023" in diameter; and for plain Diesel engine oil, and the same fuel with 0.3 of one percent anti-knock dope. The room (inlet air) temperature could not be closely regulated during these runs, which caused some irregularity in the curves.

Fig. 7 shows the marked effect of inlet air temperature on the final compression pressure necessary for starting. The inlet air temperature was varied from 67°F. to 121°F. with a corresponding change in the compression pressure from 391 lb. to 336 lb. gage as taken from Fig. 2. Since the curves of Fig. 2 were obtained for air at 65°F., it follows that, with air at temperatures higher than 65°F., the compression pressure would be less than represented on Fig. 2. Hence the effect of air temperature is even greater than shown on Fig. 7.

The results show the sensitiveness of this compression ignition engine to changes in final compression pressure, induced by a change in the initial compression pressure, and suggest the necessity, as regards a compression ignition engine, of providing some compensating means for conditions that tend to lower the suction pressure. Although reliable ignition at high altitudes might be obtained by heating the inlet air, more uniform operation, higher capacity and greater ease in regulation could probably be obtained from some form of supercharging. Furthermore, some of the heat developed during compression in the supercharger would be available to aid in effecting compression ignition.

Fig.1.

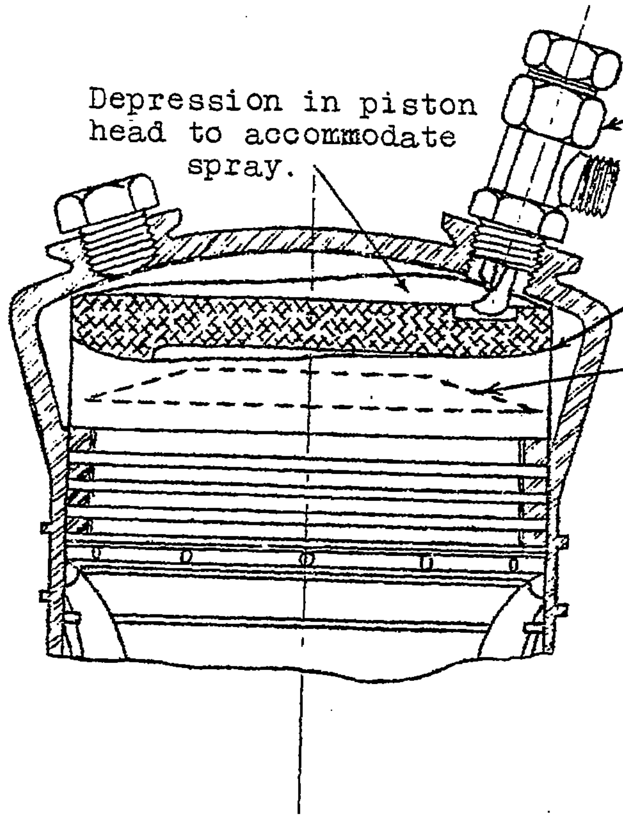


Fig.1. Section of Liberty cylinder combustion chamber without water jacket.
5" bore, 7" stroke.

Fig.2.

Starting conditions
1 cylinder Liberty engine
compression ignition.

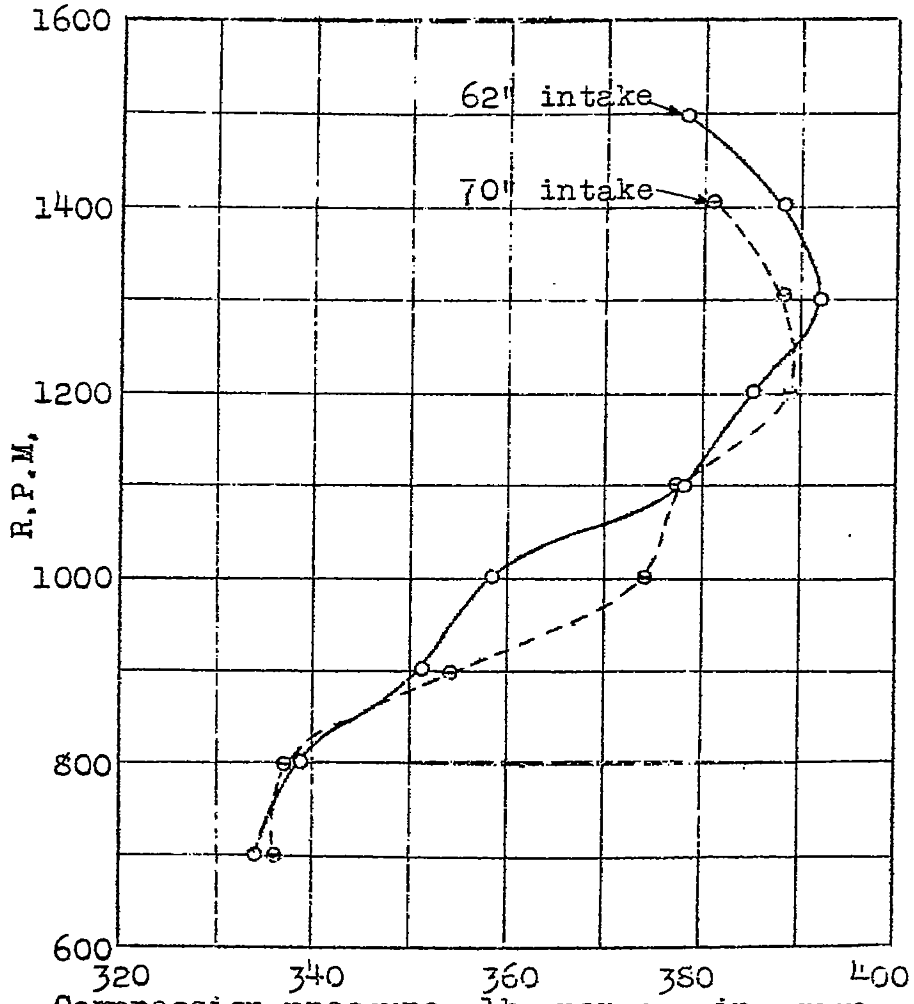
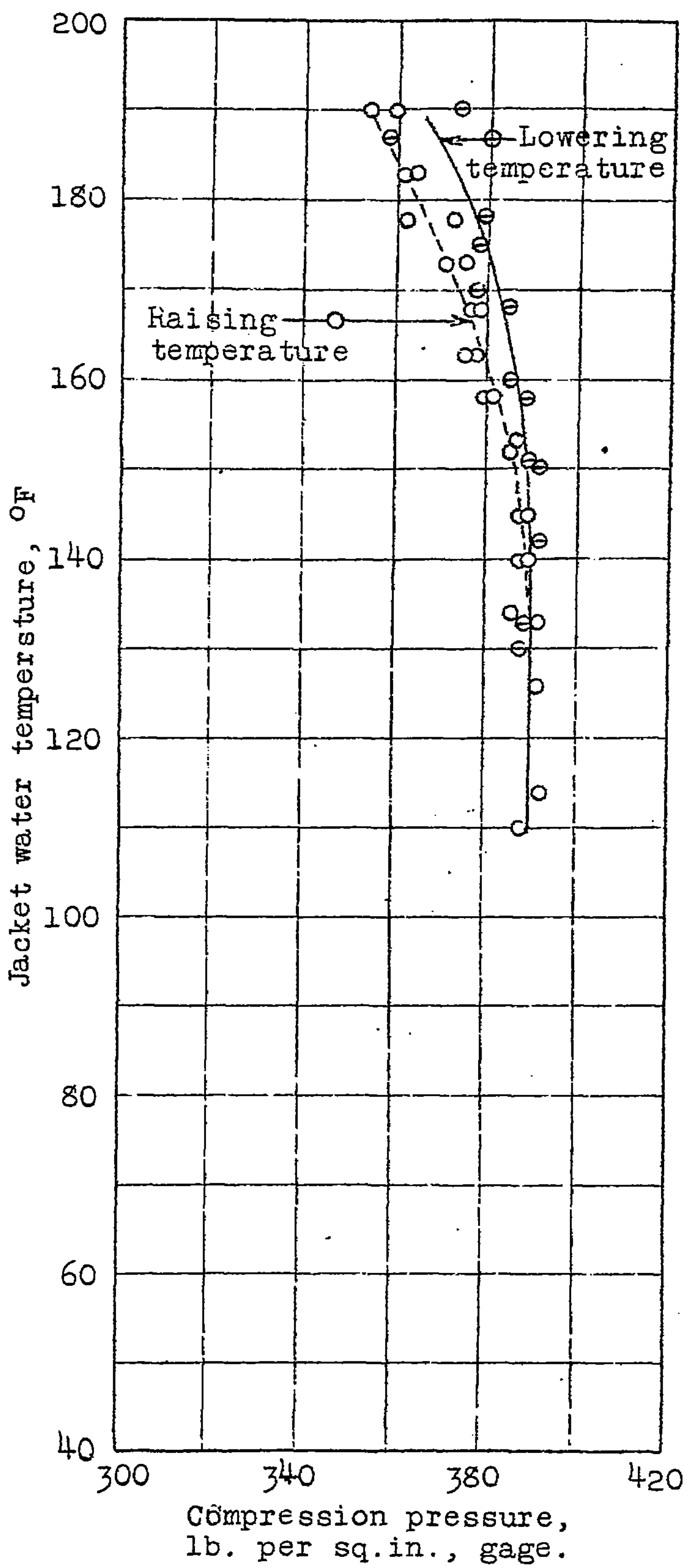


Fig.2. Increase of compression pressure with R.P.M. for long intake pipe. Compression ratio 11.4

Fig. 3



STARTING CONDITIONS

1 Cylinder
Liberty engine

Compression
ignition.

Intake pipe length
62" and 70"

--

Decrease in
compression pressure
required
with increase in
jacket temperature

--

.023 inch dia.
nozzle orifice

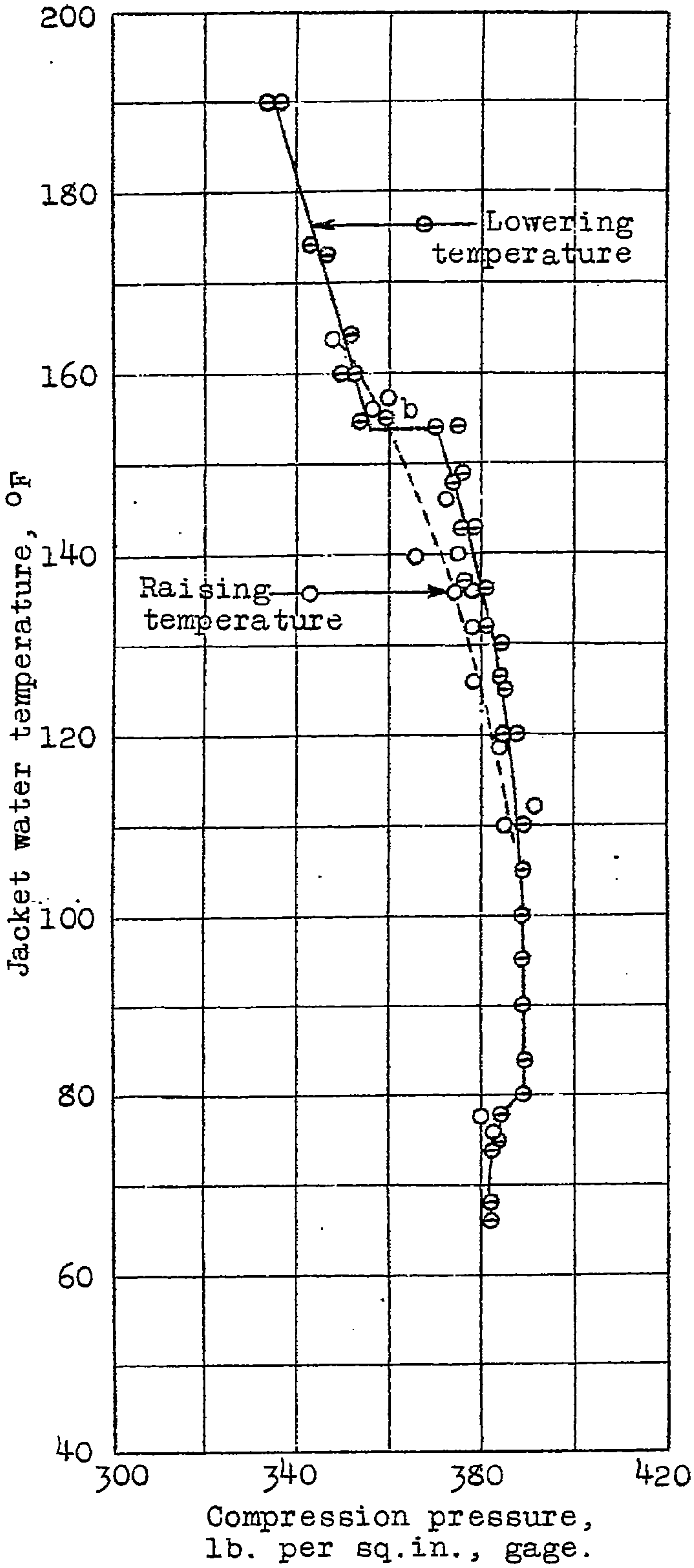
--

Fuel:-
Diesel engine oil with
.3 of 1% anti-knock dope.

--

Compression
ratio - 11.4

Fig. 3



STARTING CONDITIONS

1 Cylinder
Liberty engine

Compression
ignition.

b = Break in curve
attributed to change
in room temperature
on successive days.

Decrease in
compression pressure
required
with increase in
jacket temperature

--

.023 inch dia.
nozzle orifice

--

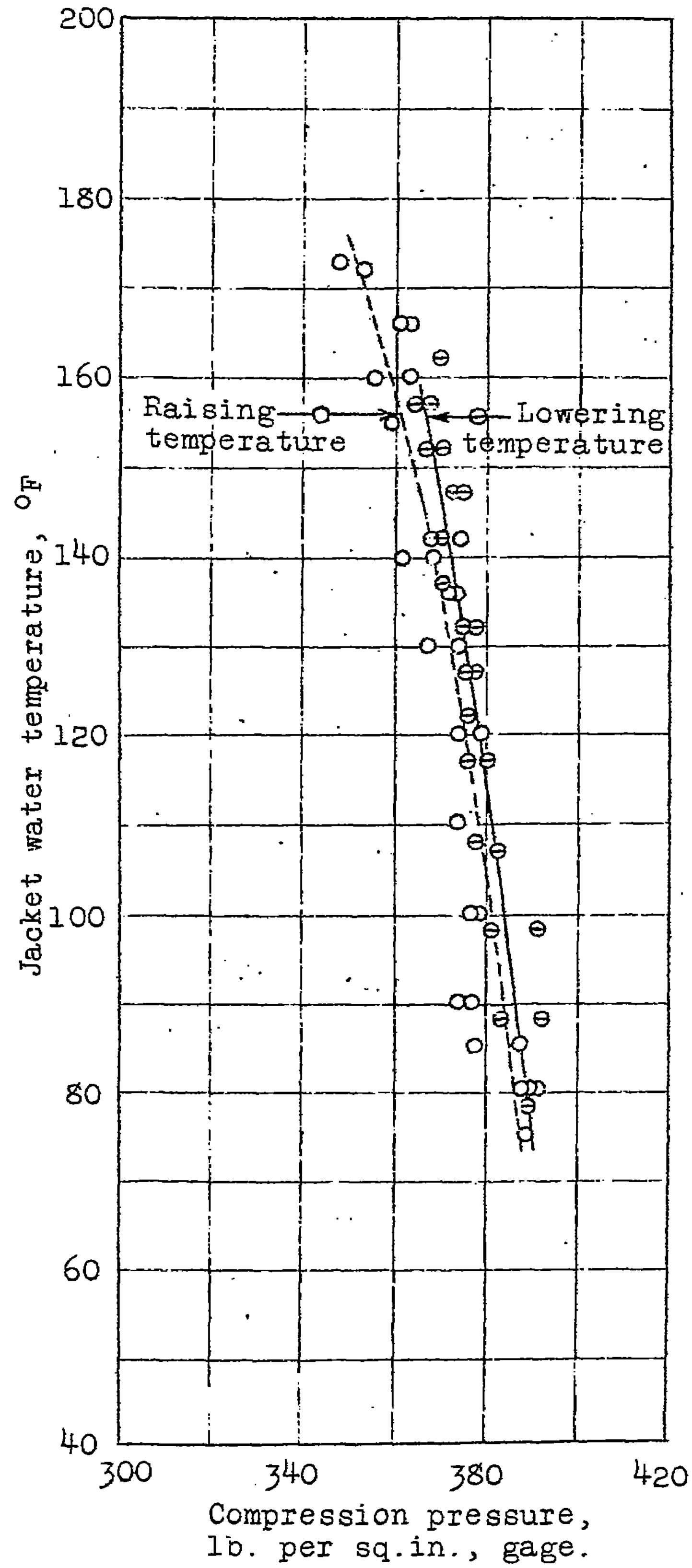
Fuel:-
Diesel engine oil
(plain)

--

Compression
ratio - 11.4

Fig. 4

Fig. 5



STARTING CONDITIONS

1 Cylinder
Liberty engine

Compression
ignition.

Decrease in compression pressure required with increase in jacket temperature

--

.014 inch dia. nozzle orifice

--

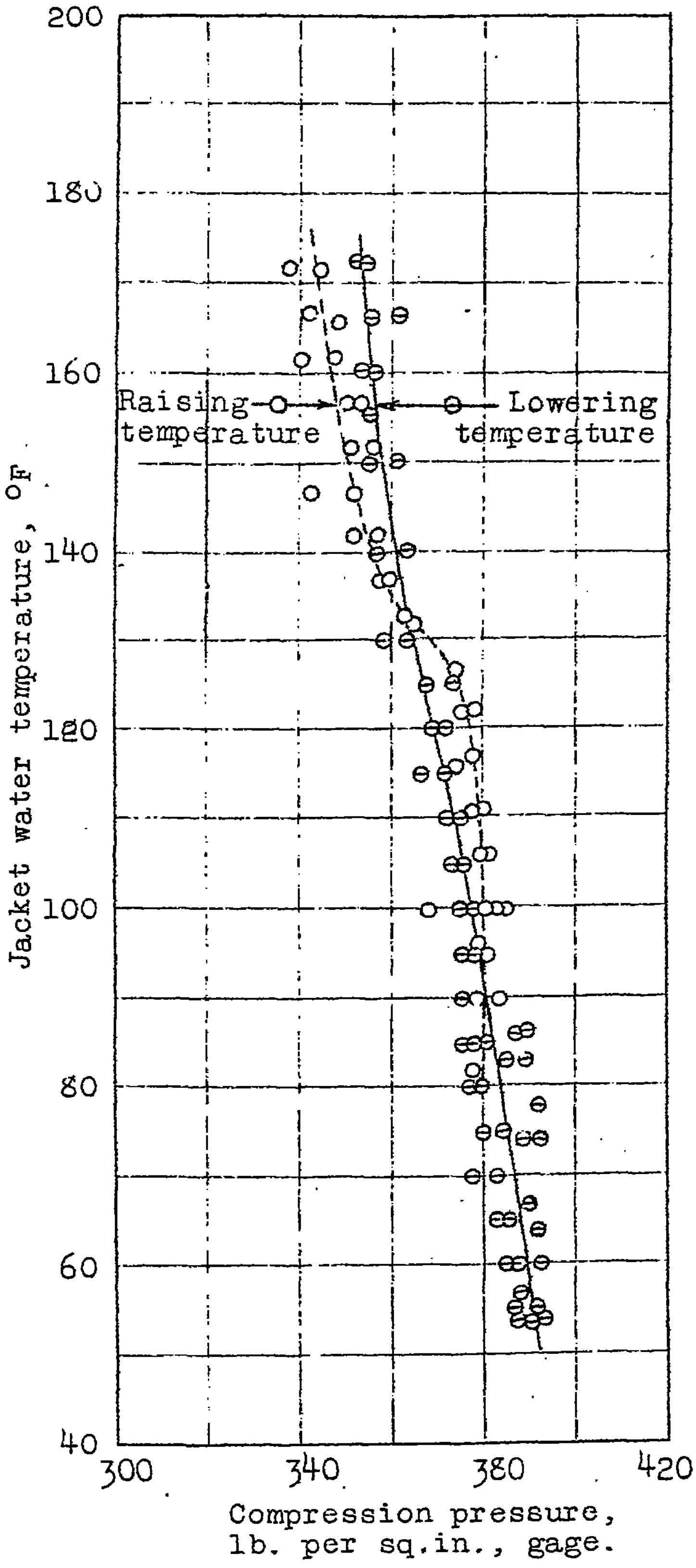
Fuel:-
Diesel engine oil with .3 of 1% anti-knock dope

--

Compression ratio - 11.4

Fig. 5

Fig. 6



STARTING CONDITIONS

1 Cylinder
Liberty engine

Compression
ignition.

Decrease in
compression pressure
required
with increase in
jacket temperature

--

.014 inch dia.
nozzle orifice

--

Fuel:-
Diesel engine oil
(plain)

--

Compression
ratio - 11.4

Fig. 6

Fig.7.

Starting conditions
1 cylinder Liberty engine
compression ignition.

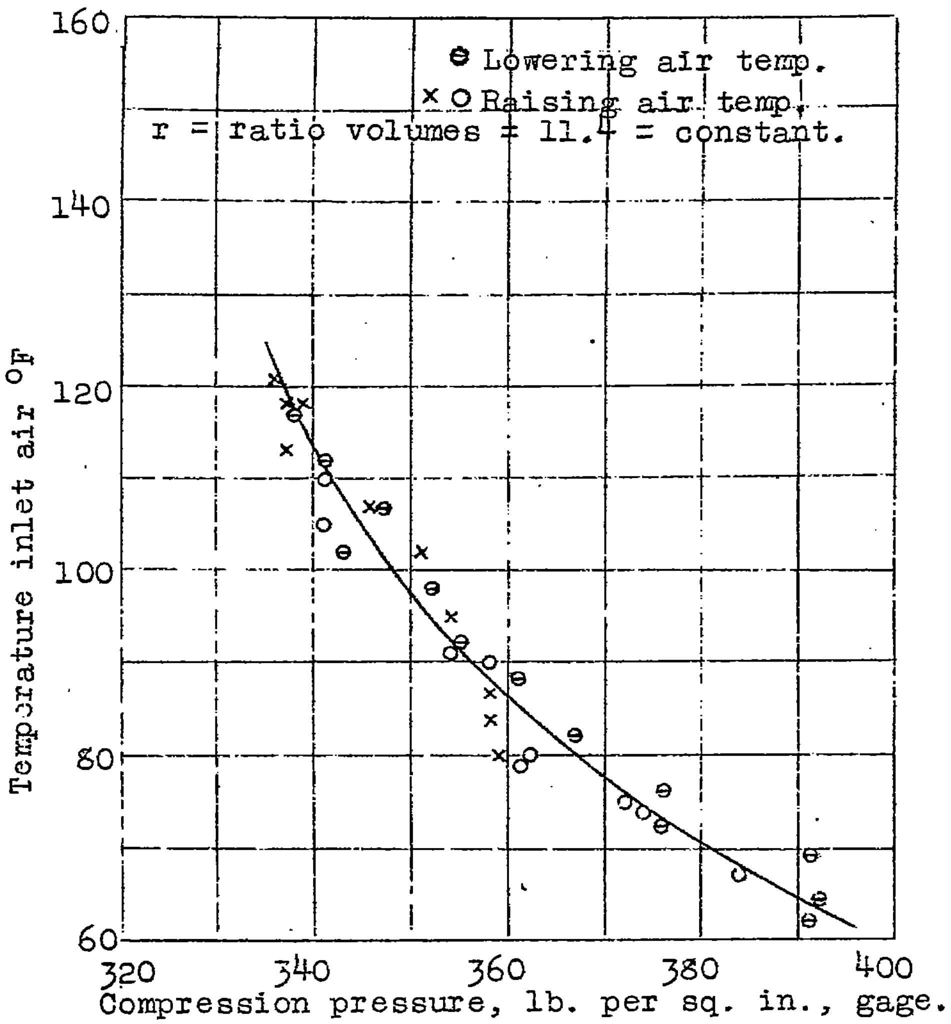


Fig.7. Decrease in compression pressure required with increase in inlet air temperature. Compression ratio 11.4.